

Method, software and apparatus for segmenting a series of 2D or 3D images

The invention relates to a method and to an apparatus having means for segmenting a series of 2D or 3D images obtained of a patient's organ or other body part, wherein a first segmentation is carried out on a first image of the series of images and wherein the first segmentation is used for the subsequent segmentation of the remainder of
5 images of said series of images.

Such a method and apparatus is known from US-A-5,903,664, showing a cardiac segmentation system acquiring a series of images as slices through a volume, and as
10 images at different time periods throughout a cardiac cycle. In this known system and method a first image of a series of images is segmented by making use of a threshold. The centroid of this image is used as a seed point in segmenting adjacent images. This is repeated for a number of images in order that all images are accordingly segmented.

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It is an object of the invention to improve the reliability and versatility of the known method and apparatus for segmenting a series of 2D or 3D images, whereby the segmenting still can take place with little or without human intervention.

It is also an object of the invention to provide a method and apparatus, which
20 allow for easy and swift comparison between different sets of images.

These and other objects of the invention which will become apparent from the discussion below, are accomplished in that while in use the apparatus of the invention carries out a series of transformations in relation to the images, wherein each separate transformation embodies a fitting operation between two images of said series of images, and wherein
25 substantially all images of the series of images are subjected to such a transformation, whereby the first segmentation on the first image of the series of images is modified and subsequently applied to any further image of the series of images according to the transformation or sequence of transformations that fits the said first image to said further image of the series of images.

The invention is also embodied in the method and in software operated by the apparatus, which method and software are characterized in that in relation to the images a series of transformations are established wherein each separate transformation embodies a fitting operation between two images of said series of images, and wherein substantially all
5 images of the series of images are subjected to such a transformation, and that the first segmentation on the first image of the series of images is modified and subsequently applied to any further image of the series of images according to the transformation or sequence of transformations that fits the said first image to said further image of the series of images.

It is envisaged that any type of segmentation can be applied initially as the
10 first segmentation on the first image. This segmentation can be carried out either manually or (semi) automatically by means and methods that are known per se in the art. The result of this segmentation which can be moulded according to the needs of the user, is according to the invention simply and quickly propagated to the other images of the series of images.

The said transformation among the respective images of the series can be
15 applied for instance between the said first image of the series of images and each of the further images of such series of images. It is, however, preferred that each transformation relates to adjacent or immediately successive images of the series of images. The differences between adjacent or immediately successive images of said series of images are rather limited allowing that the accuracy requirements of the transformation remain fairly limited.

20 An important benefit of the invention lies in that it proves particularly useful when there are two or more series of images, whereby the segmentation applied to the first series of images can also be applied to the other series of images. This allows for ease of comparison among the said series.

The just mentioned advantage is immediately apparent when the method is
25 applied to, or the apparatus operates on series of images that are collected with different means of monitoring selected from the group MR, CT, NM and US.

It is further useful that the respective series of images, whether being collected with the same means of monitoring or with different means of monitoring, are collected at different times.

30 The method according to the invention applies to all types of organs and other patient's body parts. When the images, however, relate to a substantially sphere-like organ such as a heart, the apparatus, software and method according to the invention are preferably characterized in that prior to establishing the said series of transformations, the series of images are converted to a modified series of images showing the walls of the organ in a flat

plane wherein the left and right part of said plane substantially correspond to the inside and outside of said organ, and that the said series of transformations are applied to the modified series of images. By this measure of converting the initial series of images to a modified series of images, the processing according to the invention can be substantially alleviated
5 allowing for rapid processing of large amounts of images without sacrificing accuracy.

The invention shall hereafter be further elucidated with reference to the drawing.

10 In the drawing:

Fig. 1 shows a schematic flow sheet of the operation of an apparatus according to the invention;

Fig. 2 shows schematically an image of a heart and a modified image thereof;
and

15 Fig. 3 shows the modified image of the heart in two subsequent images.

The invention applies to processing of both 2D and 3D images. For medical diagnosis, therapy planning and monitoring of the effect of therapy it is often required to
20 accurately segment various anatomical structures that are present in medical images of the patient. Medical image segmentation has therefore received considerable attention during the last few decades.

Many segmentation algorithms have been proposed, ranging from methods based on thresholding (see US-A-5,903,664) to advanced methods such as 2D active-contour
25 or 3D active-object based segmentation.

Whatever the type of segmentation, which may also include manual segmentation, the invention proposes an apparatus and method which make it easy to apply the selected segmentation to all images in a series of images or to several series of images, whereby it is only required to apply an initial segmentation to a selected first image of the
30 series of images.

With reference now to Fig. 1, the general working of the apparatus and method according to the invention is explained. An image 1 undergoes a segmentation in box 2 resulting in a desired segmented image 3. The said first image 1 and consecutively further images i , whereby i may range from 2 to n , are supplied to a box 4 in which a transformation

$T_{1,i}$ is calculated in order to arrive at a best fit of image 1 and image i . This transform $T_{1,i}$ is supplied to a box 5, which also receives the initial segmented image 3 and which converts these both information flows into a segmented image 6 corresponding to the original image i . The apparatus of the invention repeats this process for every i in the range 2 to n , so that in relation to a region of interest of the concerning images, a series of transformations are established, wherein each separate transformation embodies a best fit between two images of said series of images, and wherein each image of the series of images is subject of such a transformation. Although Fig. 1 relates to each individual transformation among images such that always image 1 forms part thereof, it is also possible that each individual transformation relates to adjacent or - in other words - immediately successive images of the series of images.

The invention is also applicable when there are two or more series of images whereby the segmentation of the first series of images (which is based on the segmentation of the first image from this first series of images) applies to all series of images.

It is in this respect possible and at times advantageous that the respective series of images are collected with different means of monitoring the patient, which means are selected from the group MR, CT, NM and US. The respective series of images may also be collected at different times.

With reference to Fig. 2, it is shown that the images (one of which is shown in the left-hand part of Fig. 2) may relate to a substantially sphere-like organ such as a heart. In such a case, it is desirable that prior to establishing the above explained series of transformations, a conversion of the image of the heart shown at the left-hand part takes place to a modified image as shown in the right-hand part of Fig. 2. This type of transformation is known as a resample operation and results in a showing of the walls of the concerning organ in a flat plane, wherein the left- and right-hand part of said plane substantially correspond to the inside and outside of the concerning organ. The ease of working of the apparatus and method of the invention is highly supported by this prior operation allowing that the transformation can take place to the modified image which is simpler to operate. An example of this is shown with reference to Fig. 3.

Fig. 3 shows at the left-hand part an image i and on the right-hand part a subsequent image $i+1$. The region of interest of these images is the so-called myocardium of the left ventricle of the heart, the position of which is indicated in the left-hand Figure by r_1 - r_2 . In the right-hand part of the Figure relating to image $i+1$ this position has changed to \underline{r}_1 - \underline{r}_2 .

The change in position from r_1-r_2 to $\underline{r}_1-\underline{r}_2$ represents the transformation that fits image i to image $i+1$ and which is used for applying the segmentation of image i to image $i+1$.

It is remarked that the above merely represents one example of executing the transformation as part of the method according to the invention and that there are numerous other ways of executing this transformation within the scope and spirit of the invention as defined by the appended claims.